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GEOLOGY.—*Variations in Appalachian stratigraphy.*[1] CHARLES BUTTS, U. S. Geological Survey.

The truly scientific investigation of the stratigraphy of the Appalachian Valley may be said to have begun in the period 1835–1842 with the work of W. B. Rogers in Virginia and H. D. Rogers in Pennsylvania. They recognized the broad outlines of the stratigraphic succession and reached a substantially correct understanding of the general geologic structure. In the period 1855–1869 Safford studied and described the geology of Tennessee, making finer subdivisions than the Rogers brothers had done and introducing the British and New York classification and systemic names. Still later, from 1875 to 1885, the Second Geological Survey of Pennsylvania made still finer subdivisions of the stratigraphic column and followed still more closely the New York classification. In 1894 the report on the Paleozoic rocks of Alabama, prepared mainly by Henry McCalley under the direction of E. A. Smith, the State Geologist, was published. Here also the general British, Canadian and New York classifications were followed. In both the Alabama and Pennsylvania reports the stratigraphic subdivisions were in part of a broad, inclusive character. For example, it has been found possible to break up formation No. II of the Second Survey of Pennsylvania into 14 mappable units, ranging from Middle Cambrian to Trenton in age, and in Alabama the "Pelham limestone" included rocks from middle Beekmantown to rocks of upper Richmond age and was thus nearly synonymous with Ordovician in the broadest sense.

Subsequent to 1880 large areas of the Valley were mapped in greater detail than ever before by the geologists of the U. S. Geological

[1] Address of the retiring president of the Geological Society of Washington, delivered December 14, 1927. Received May 8, 1928. Published by permission of the Director of the U. S. Geological Survey.

Survey, Hayes, Keith, Campbell, and Darton. They had the aid of fair topographic maps, which were wanting to their predecessors. Their work consisted mainly in mapping the various lithologic units, and their discrimination of the map units was in general satisfactory and the mapping carried out consistently. Owing, however, to the almost complete neglect of paleontology, various errors were made in correlation and identification of formations in different belts of outcrop within the Valley. For example, the shale of Martinsburg age of the northwestern belts in Tennessee and Virginia (Trenton to Maysville ages), was identified with the much older Sevier shale (of upper Chazy age) of the southeastern belts. The lower part of the Sevier really corresponds to the Ottosee limestone of the northwestern belts, which is separated from the younger Martinsburg shale by the Moccasin limestone. In like manner the essential equivalency of that part of the Chickamauga limestone corresponding to the Lowville limestone in the most northwestern belts adjacent to the coal fields with the Moccasin limestone of the middle belts and the Bays sandstone of the southeastern belts was not recognized.

It remained for one who through years of intensive paleontologic and stratigraphic studies had become a master of the criteria by which alone correct stratigraphic correlation is possible to point out such errors as I have mentioned and put the systematic stratigraphy of the Valley on a sound basis. I refer, of course, to Ulrich, who began work in the southern Appalachians in 1896, and in 1902, after a few seasons' work zigzagging back and forth across the Valley, published in collaboration with Schuchert, the paper on *Paleozoic Seas and Barriers* (Bulletin 52 of the New York State Museum). In this paper the basic concepts of the authors regarding the history of Appalachian deposition as suggested by the distribution of the deposits were set forth. Briefly their thesis was that the Appalachian geosyncline was occupied by a number of subordinate, relatively long and narrow troughs of deposition, having in part separate oceanic connections, and separated by long narrow barriers. They thought that at times the geosyncline was almost entirely submerged and contemporaneous deposition extended clear across it and along nearly its whole length. Ulrich continued work in the Valley and in 1911 his great work, the *Revision of the Paleozoic Systems*, was published. In this he elaborated or modified the ideas set forth in *Paleozoic Seas and Barriers*, and applied them to the revision of the classification of the Paleozoic strata up to the top of the Beekmantown, which he included in his

Canadian system. The idea of long, narrow barriers was largely abandoned and the idea of continental tilting and shifting of troughs of deposition was stressed.

My own connection with this work has been mainly in detailed mapping for folios and State maps all along the Valley from Pennsylvania to Alabama, and in this I have, of necessity, had to depend upon Ulrich for precise stratigraphic correlation. I have had opportunity to check to a large extent Ulrich's determination of stratigraphic equivalency and it is my purpose in the rest of this address to present some concrete examples of stratigraphic variations that have come under my own observation, point out their possible causes, and show their possible bearing upon Ulrich's general hypothesis of local warping and shifting troughs in the Appalachian geosyncline.

The variations of which I shall speak are of two kinds—variations in the sequence of formations from place to place and variations in the character of the same formation in different parts of the Valley, or facies variations.

I will first take up the variation in sequence and afterwards the variations in facies.

General Sequence of Formations

The general formational sequence in the Valley is fairly well displayed in the group of sections shown in Figure 1.

At the base of the Paleozoic succession a group of quartzites and shales of Lower Cambrian age rests upon the Archean rocks of the Appalachian Mountains or on those of the Piedmont plateau. These Cambrian rocks border the Appalachian Valley on the southeast from Pennsylvania to Alabama. They make the Blue Ridge for much of the distance from Potomac River to Roanoke, Virginia. They are variously subdivided and named but in general may be appropriately designated by Safford's name Chilhowee sandstones and shales or, more briefly, the Chilhowee group. (See Figure 1, section 6.)

The overlying Shady limestone, mainly dolomite, is persistent and fairly uniform in character throughout the length of the Valley. The same is true of the next overlying Watauga shale, to which other names have been given in different areas, as Rome in parts of Georgia, Alabama, and Tennessee, Waynesboro in Pennsylvania, "Russell" on the northwest side in Virginia, and "Buena Vista" in the vicinity of Lexington, Virginia. Recently the U. S. Geological Survey has adopted the name Watauga shale for the southeast side of the Valley

in Virginia and the name Rome formation for the belts on the northwest side in which the name "Russell" has formerly been used. The writer would prefer to abandon all other names as synonyms and apply the prior name Rome throughout, for the unit is generally acknowledged to be substantially the same from end to end of the Appalachian Valley. The next overlying unit, Honaker limestone, is persistent but of variable facies, as will be shown later. The Nolichucky shale, succeeding the Honaker, is well-defined in northern Tennessee and southern Virginia but loses its identity north and south of that general region.

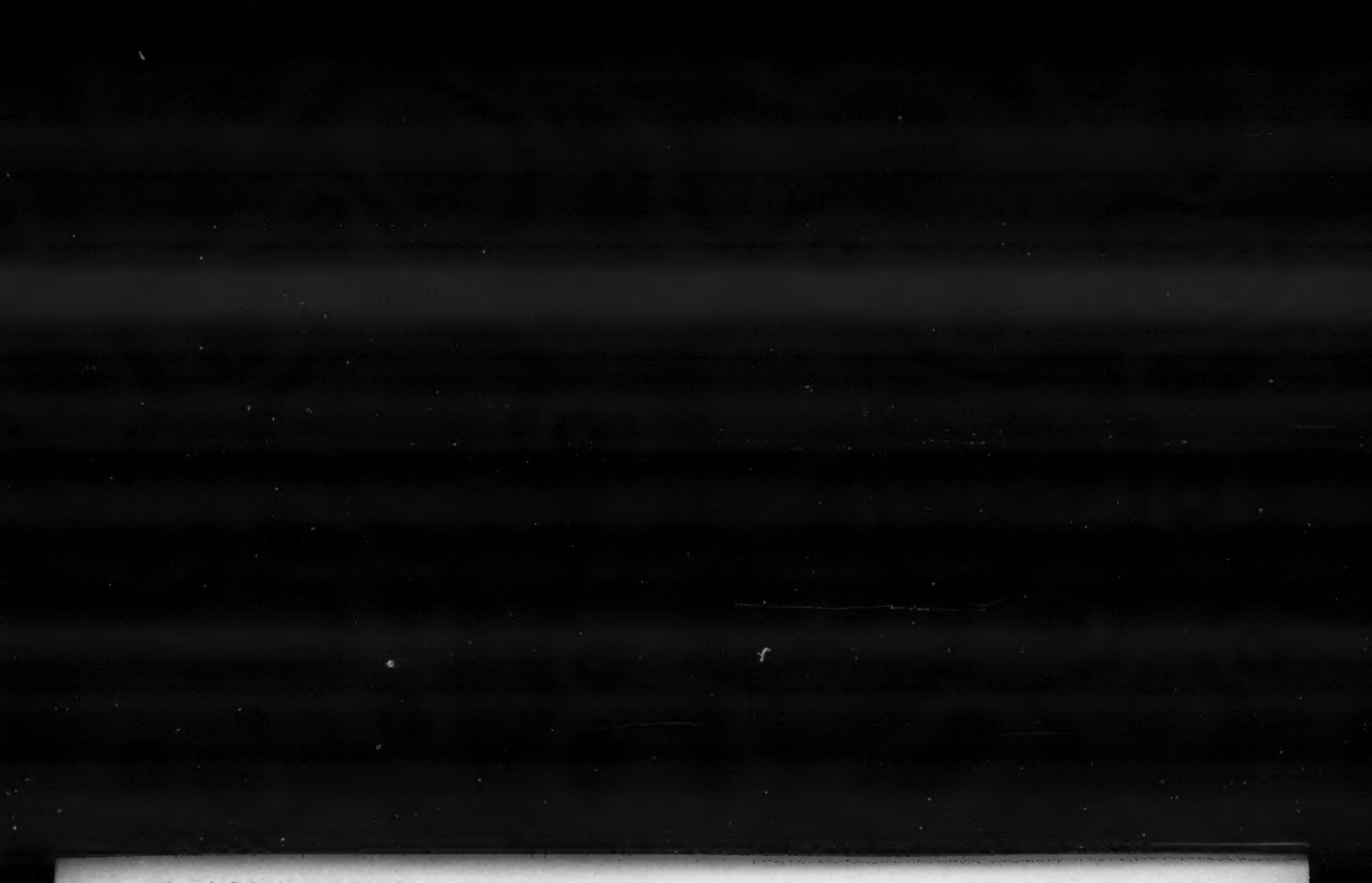
Next above the Nolichucky is the Jonesboro limestone in the southeastern belts of outcrop and the Copper Ridge dolomite in the northwestern belts. The relationship of these will be discussed farther on.

Succeeding the Jonesboro (as here redefined), or the Copper Ridge, according to locality, is the Nittany dolomite, containing the *Lecanospira* zone—one of the great persistent units, extending in faunal and lithologic integrity throughout the Valley. This general zone is known to persist from the northwest highlands of Scotland (Durness limestone, in part) via Newfoundland, Quebec, Lake Champlain and the Appalachian Valley to southern Missouri, where it is represented by the Roubidoux formation. The zone is everywhere marked by its characteristic genus of gastropods, of which Ulrich recognizes several species, the genotype being *"Ophileta" compacta* Salter. The genus is, however, quite distinct from *Ophileta*, and Ulrich has given to it the name *Lecanospira*.

The Nittany is overlain by 50 to 200 feet of beds containing the gastropod genus *Ceratopea*, which are in turn succeeded by the Mosheim limestone, and that by the Lenoir limestone. The Lenoir limestone represents the middle Chazyan Crown Point limestone of the Lake Champlain region and contains the well known *Maclurea magna* zone. The Lenoir is represented in the northwestern belts in the Stones River limestone shown in Figure 1, section 2.

The Lenoir is followed by coarse limestone or marble named Holston marble in Tennessee and Holston limestone in southwestern Virginia. This unit has also been called Murat limestone in Rockbridge County and neighboring parts of Virginia.

Next in upward sequence is the Athens shale, carrying the Normanskill graptolite fauna. At Knoxville, Tennessee, the Athens is absent and the Holston marble is directly succeeded by the Tellico sandstone. The Tellico is succeeded in turn by the Sevier shale, the lower part of



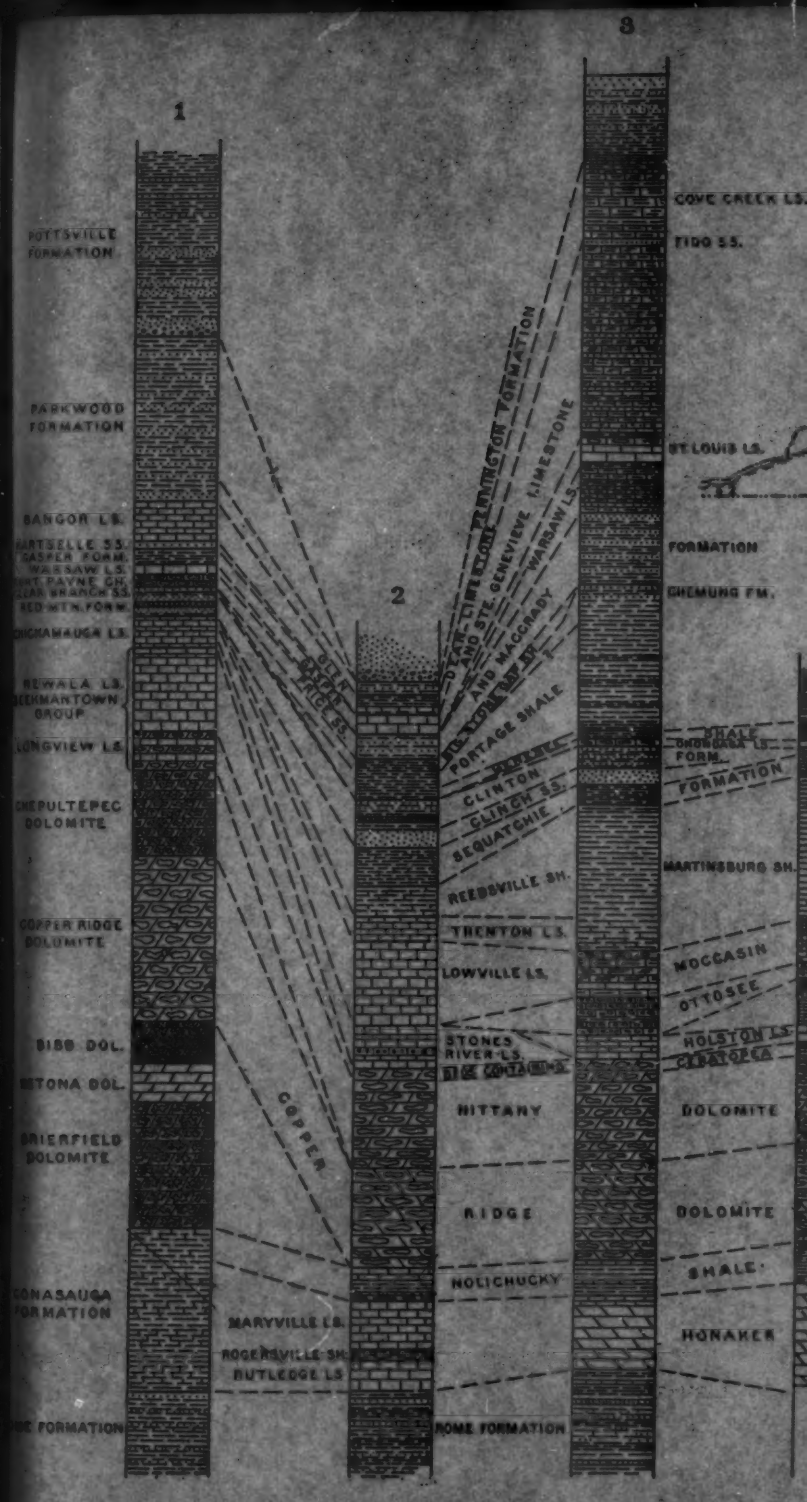
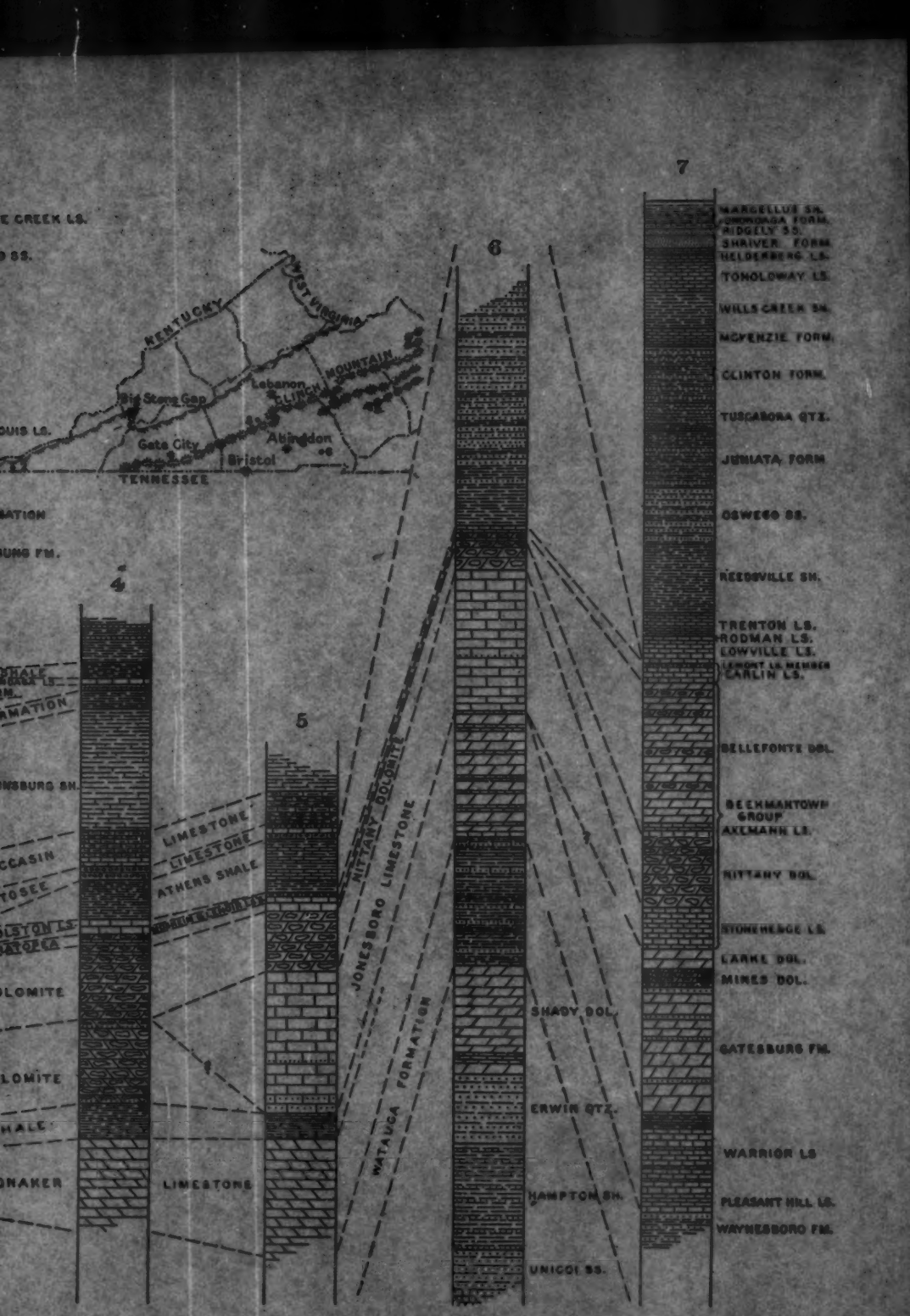


Figure 1.—Sections showing stratigraphic sequence in Alabama, Virginia, and Pennsylvania. Section No. 1 is in the Birmingham District, Alabama, the part above the Chickamauga limestone in Birmingham Valley, the part below the Chickamauga



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Cahaba Valley; sections Nos. 2 to 6 in southwestern Virginia, as shown in key map; section No. 7 in Center, Huntingdon, and Blair counties, central Pennsylvania. Scale of sections 1 inch = 2,000 feet.

which is represented in the northwestern belts in Tennessee and throughout southwestern Virginia by the Ottosee limestone. This new name was given by Ulrich to a smaller unit of a very different facies in the northwest part of the Valley. Northwest of Clinch Mountain in Tennessee and throughout the areas covered by folios in southwestern Virginia, the Martinsburg shale was erroneously identified and mapped as Sevier shale, whereas the actual representative of the typical Sevier (with its basal calcareous part now called Ottosee) was included in the Chickamauga limestone.

Next above the Ottosee in the middle belts is the Moccasin limestone, which is approximately the same as the Lowville limestone of the northwestern belts, as shown in section 2, Figure 1. The Moccasin is succeeded in the middle belts by the Martinsburg shale, which includes in its lower part the equivalent of the true Trenton limestone. In the northwestern belts the Trenton becomes recognizable as a limestone and the post-Trenton part of the Martinsburg, composed largely of shale, is made a separate formation, named the Reedsville shale.

Overlying the Reedsville or Martinsburg, according to locality, a formation composed mainly of red shale and sandstone extends throughout most of the Valley from Pennsylvania to southwestern Virginia. In Pennsylvania it is named the Juniata formation, but in southwestern Virginia, where marine fossiliferous limestone comes into it, it is named the Sequatchie formation. This unit was wrongly called Bays sandstone in the southwestern Virginia folios, the typical Bays, as said before, being equivalent to the older Lowville or Moccasin limestone.

The Sequatchie or Juniata is succeeded throughout the Valley and southward to central eastern Tennessee by a ridge-making quartzite called Tuscarora in Pennsylvania and Clinch in Virginia. It makes the crest of Clinch Mountain. The Clinch or Tuscarora is followed by the Clinton formation, so well known through the Valley from New York to Alabama on account of its deposits of stratified iron ore.

Next above the Clinton in Pennsylvania, Maryland, and northern Virginia, lie shale and limestone of Cayuga age, followed in turn by the Helderberg limestone. The Helderberg, however, does not extend southward in Virginia to the region covered by the sections, although in the extreme northwestern belts adjacent to the coal fields, as in the vicinity of Big Stone Gap, both Cayuga and late Helderberg are represented. In southern Virginia, in the middle belts, the Clinton is

overlain by a thin representative of the Oriskany sandstone and that by limestone and chert of Onondaga age. This is followed in turn by black shale of Marcellus and Genesee age, and the latter by a varying thickness of Upper Devonian shale and sandstone in the main representing the Portage and Chemung formations of western New York.

Next above the Chemung comes the basal Mississippian Price formation, of New Providence (Burlington, Pocono) age, and this is followed by later formations of Mississippian (Meramec and Chester) ages up to the Pennington formation. Southeast of Clinch Mountain there is a hiatus due to the absence of beds of Keokuk age, and on the northwestern side of the Valley this hiatus is increased by the additional absence of the Warsaw and most of the St. Louis limestones.

Variations in Sequence

Intercalation of the Blount Group of Ulrich.—I have selected a few of the more clear-cut and extreme variations for presentation. The first is the intercalation of the Blount group of Ulrich along the strike between Pennsylvania and Alabama, as illustrated in Figure 2. In this figure the photograph on the right, turned a quarter way around to facilitate drawing the correlation lines, is a view in one of the quarries at Bellefonte, central Pennsylvania. The strata dip 50° northwest. At the top, above the junction of the correlation lines, is the Lowville limestone; just below the junction of the lines is the Lemont member of the Carlim limestone, of Chazy age.

The Lemont here is only 10–15 feet thick and at both its top and bottom is a bed of clayey composition not more than 1 foot thick, identified by Ross and others as volcanic ash or what has recently been identified by them as bentonite, which occurs at several horizons and which has been found at many places in the Appalachian valley and the more interior parts of the eastern United States.

The limestone above the Lemont is known to be Lowville from the presence of its guide fossils, *Tetradium cellulosum*, and *Cryptophragmus antiquatus* (*Beatricea* of Ulrich). The Lemont is known to be of middle Chazy age by the presence in it in some localities in central Pennsylvania of the well known guide fossil *Maclurea magna* as well as the occurrence of other equally good middle Chazy fossils.

Going south to the general region marked by Knoxville, Tennessee, the Lemont limestone is represented by the Lenoir limestone, with *Maclurea magna* and a profusion of other fossils, and the Lowville limestone is represented southeast of Knoxville by the Bays sandstone. This is proven by the occurrence of *Tetradium cellulosum* in limestone

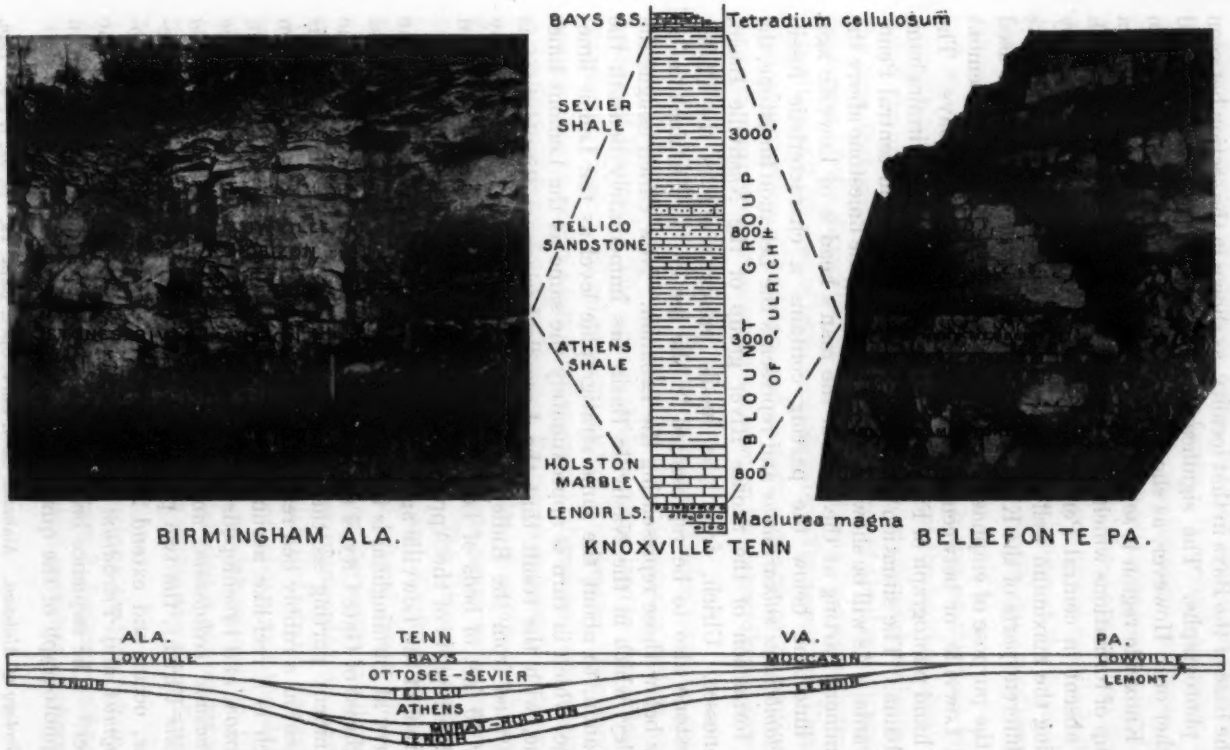

Figure 2.—Photographs and sections to show the stratigraphic relations and geographic distribution of the Blount group of Ulrich. Note the parallelism of the bedding at the unconformities shown in the photographs.

in the base of the Bays in that locality, as shown in the section between the photographs. The significance of this fossil will be discussed further on. However, as shown in Figure 2, the Lenoir limestone in the Knoxville region is separated from the beds of Lowville age by a group of formations which aggregate 7,500 feet in thickness and which are absent in central Pennsylvania. This thickness is obtained by taking the maximum well-determined thicknesses of the several units in different parts of the Knoxville region. These thicknesses are used for the purpose of emphasizing the time interval between the Lemont and Lowville, or between their equivalents, Lenoir and Bays. The left hand photograph of Figure 2 is a view of a quarry in Birmingham, Alabama. The situation is here nearly the same as in central Pennsylvania. As will be shown a little further on, the limestone above the prominent parting at the level of the man's head is of Lowville age; the limestone below the parting contains a characteristic fossil, *Plectambonites subcarinatus* and represents the Lebanon limestone, the top formation of the Stones River group of the Nashville Basin, Tennessee. Ulrich, from the fossils present, believes the Ridley limestone also to be represented in the section at Birmingham by beds below those representing the Lebanon. Now Ulrich assigns the Ridley, which in the Nashville Basin lies immediately beneath the Lebanon, to about the same stratigraphic level as the Lenoir limestone, which in turn is approximately the same as the Lemont limestone, with the result that the Lowville horizon at Birmingham is separated from the Ridley horizon (possibly Lenoir or Lemont) by only 50 feet of beds of Lebanon age not present in the eastern and northern parts of the Appalachian valley.

Proof of the Lowville age of the limestone above the parting in the quarry at Birmingham is found at a quarry on the same outcrop just northeast of Gate City, 4 miles northeast of Birmingham. The same prominent parting as that shown in the left hand photograph is present as a rubbly bed reaching a thickness of possibly a foot and on which is a reef-like accumulation of fossils, *Solenopora*, *Columnaria*, Bryozoa, and brachiopods. Ten feet above the parting at this place *Tetradium cellulosum* and *Cryptophragmus antiquatus* (*Beatricea gracilis* Ulrich), the two principal guide fossils of the Lowville limestone, occur and extend 20 feet higher. The specimens of *Cryptophragmus* and *Tetradium* collected here have been figured by the writer.[2] The sequence below the break is the same as that shown in the photograph of the quarry at Birmingham.

[2] *Geology of Alabama*. Alabama Geol. Surv. Spec. Rept. **14**. *pl. 32, f. 1–5*. 1926.

Cryptophragmus is a unique fossil; nothing like it is known from any other horizon in the Appalachians. It occurs together with *Tetradium* in an identical faunal and stratigraphic sequence from Canada to Alabama, and the two mark a continuous zone in the Lowville limestone along the northwest margin of the Appalachian Valley and in the lower part of the Moccasin limestone in the middle belts of the Valley. The *Tetradium* occurs in the limestone at the base of the Bays sandstone and just above the typical Sevier shale southeast of Knoxville, Tennessee.

A most remarkable feature of this great hiatus at the base of the Lowville limestone is the perfect parallelism of the bedding above and below the unconformity and the absence of any physical evidence that the time that elapsed between the deposition of the Lemont and the beginning of the deposition of the Lowville was long enough for the deposition of 7,500 feet of beds in northeastern Tennessee and Virginia. This concordance of bedding and perfect appearance of continuous deposition is not an occasional phenomenon but is manifested in every exposure of the sequence.

The intercalation of the Blount group of Ulrich into the general Appalachian sequence is illustrated by the diagramatic section at the bottom of Figure 2. The Athens shale is recognized in the vicinity of Strasburg, Virginia, 20 miles southwest of Winchester. It extends in one syncline or another into northeastern Alabama and was originally a continuous deposit. The Holston limestone is known as far north as Staunton, Virginia and extends 50 miles or more southwest of Knoxville, Tennessee. The Tellico sandstone seems to be restricted to the Knoxville region in a broad sense. The Ottosee limestone is known as far north in Virginia as Tazewell and Wytheville, some 40 miles north of the Tennessee line, and the typical Sevier shale, including the Ottosee in its lower part, reaches its maximum development southeast of Knoxville. It may be represented in part in Alabama by the Little Oak limestone, which in Cahaba Valley lies between the Lowville-Moccasin-Bays horizon above and the Athens shale below. At any rate, the Little Oak, as determined by Ulrich from its fossils, is of Chazy age, and this conclusion is corroborated by its stratigraphic relations. It certainly falls within the same limits as the Tellico sandstone and Sevier shale.

No actual superposition of rock units such as that shown in the diagram beneath the word Tennessee (Figure 2, bottom) is known. The diagram only represents the chronological sequence of the units

and roughly indicates their distribution along the strike of the Valley and at the same time shows the extent of the time that elapsed between the deposition of the Lowville and Lemont in Pennsylvania and between the deposition of the equivalent formations in Alabama.

Other variations along the Valley.—There are other great variations in the sequence of formations along the length of the valley. As shown in Figure 1, section 1, in Alabama there wedges in between the Copper Ridge dolomite and the Conasauga limestone, the upper part of which is equivalent to the Nolichucky shale, 2,000 to 2,500 feet of dolomite (Brierfield, Ketona, and Bibb dolomites) not present in Virginia and most of Tennessee. In Alabama also the Chepultepec dolomite, 1,000 feet thick, intervenes between the Copper Ridge dolomite and the Longview limestone, which is equivalent to the Nittany dolomite. In central Pennsylvania, as shown in Figure 1, section 7, there is the Stonehenge limestone, 600 feet thick, between the Nittany and the horizon of the Chepultepec. In Pennsylvania too, there is the Gatesburg formation, 1,750 feet thick, in the central part and the Conococheague limestone in the southeast belts of the Valley that appear to be about equivalent to the dolomite between the Nolichucky and Copper Ridge in Alabama. In the intermediate regions of Virginia and Tennessee there is therefore an important hiatus between the Nolichucky and Copper Ridge and between the Copper Ridge and Nittany. Between the Nittany and Mosheim there is a great hiatus due to the absence of a large part of the Bellefonte dolomite of central Pennsylvania, 2,000 feet thick and of the still younger St. Peter sandstone and associated formations of the Mississippi Valley. There are also great differences in the Silurian and Devonian systems that I will not touch upon.

Variations across the Valley.—Taking up now a transverse section of the Valley rocks in southwestern Virginia, about midway between Pennsylvania and Alabama, it appears that the sequence of the lower formations up to the top of the Nolichucky shale is constant. However, nothing is known of the Shady dolomite or the Chilhowee group on the northwestern side of the Valley where their horizons are not exposed. The Rome ("Russell") formation of the northwestern side is substantially equivalent to the Watauga shale of the southeast side, the Honaker limestone is about the same as the Rutledge, Rogersville, and Maryville combined of the northwestern side and the Nolichucky probably extends clear across, and is represented in the upper part of the undivided mass of dolomite and limestone in the

southeastern belts included in the Honaker in Figure 1, section 6. In the case of the Rutledge, Maryville, and Honaker, and in that of the Nolichucky, there are marked changes of facies in the different belts as will be described subsequently. At the horizon of the Copper Ridge dolomite, however, the section on opposite sides of the Valley is strikingly different. The sequence in the northwesternmost belts, as shown in sections 2, 3, and 4 of Figure 1, holds in all the belts southeastward across the strike to that part of the Valley southeast of the line of the great Pulaski overthrust. Southeast of that line the place of the Copper Ridge, namely, the space between the Nolichucky shale and the Nittany dolomite, is occupied by 2,000 feet of rock which is predominantly limestone and which in 1911 was included by Ulrich in his Jonesboro limestone. As defined by Ulrich, the Jonesboro was made to include beds corresponding to the Nittany dolomite and still higher beds to the base of the Mosheim. However, it is agreed now that the Nittany is a distinct and easily separable unit in southwestern Virginia, and the name Jonesboro limestone is here redefined and restricted to the limestone which near Jonesboro, Tennessee, underlies the Nittany dolomite and rests on the Nolichucky shale.

The change from the 1,200 feet of cherty dolomite of the Copper Ridge to the 2,000 feet of banded limestone of the Jonesboro in the distance of a mile across the strike is startlingly abrupt. In the Copper Ridge of most of the northwestern belts no limestone has been observed, but in the belt next northwest of Abingdon extending northeast along Rich Valley between Clinch and Walker Mountains—the belt nearest to the Jonesboro limestone—layers of limestone appear scattered through the main mass of Copper Ridge and there seems to be rather more limestone at the top. On the other hand, in one place or another, heavy dolomite 50 to 300 feet thick occurs between the fossiliferous limestone in the top of the Nolichucky and the limestone of the Jonesboro. On the evidence of fossils, mainly gastropods of "Canadian" (Beekmantown) types which, so far as I have observed, occur only in about the upper 1,000 feet of the Jonesboro and mainly in the upper 500 feet, as I am here restricting it, Ulrich has classed the whole formation as "Canadian" (Beekmantown). If that is correct it must be in part equivalent to the Stonehenge limestone of Pennsylvania, which it resembles lithologically. The Stonehenge underlies the Nittany, as does the Jonesboro. If too, this interpretation is correct, the difference in southwestern Virginia at this general horizon between the succession shown in sections 2 to 4 and that shown in sections 5

and 6, Figure 1, is a difference in sequence. So, although Ulrich regards the Jonesboro as all "Canadian" (Beekmantown) yet, in view of the occurrence of limestone layers in the nearest northwest belt of Copper Ridge dolomite and a considerable thickness of dolomite in the base of the Jonesboro in places, and in view of the facts, first, that no identifiable fossils have yet been obtained from the lower 1,000 feet of the Jonesboro to prove its age, and, second, that in some cases formations of dolomite to the northwest change to limestone to the southeast side of the Valley, the possibility that the lower two-thirds or so of the Jonesboro is a limestone facies of the Copper Ridge or possibly of Copper Ridge and Chepultepec, should not be excluded from consideration. This subject will be touched upon again.

The Nittany dolomite is one of the persistent units extending both the length and breadth of the valley, and marked throughout by *Lecanospira*.

Above the Nittany and immediately succeeding *Ceratopea* zone in the middle and southeastern belts of the valley, the Mosheim and Lenoir limestones and the Blount group of Ulrich are present but in the northwest belt represented in section 2, Figure 1, they are not present. Except possibly in Mosheim time the northwest side of the Valley seems to have been separated by a barrier from the middle and southeastern sides so that the Stones River group on the northwest and the Lenoir limestone on the southeast were deposited in separate troughs, as shown by the almost complete difference of their fossils. No species, or very few, are common to the Stones River and Lenoir, although the Lenoir and Stones River seas were in part contemporaneous.

The Holston limestone occurs in the first two belts northwest of Clinch Mountain but no farther northwest. This formation has been proved to be the same as the Murat limestone, occurring in the vicinity of Lexington, Virginia, but Holston is the older name. The Athens shale nowhere extends northwest of Clinch Mountain, which indicates that that region was land in Athens time. The Ottosee limestone extends farthest northwest, being present in Rye Cove, 8 miles northwest of Gate City, and at the southeast base of Big A Mountain in Russell County. The land that existed northwest of the line of Clinch Mountain during Athens time was submerged in Ottosee time. The Ottosee extends southeastward to the belt next southeast

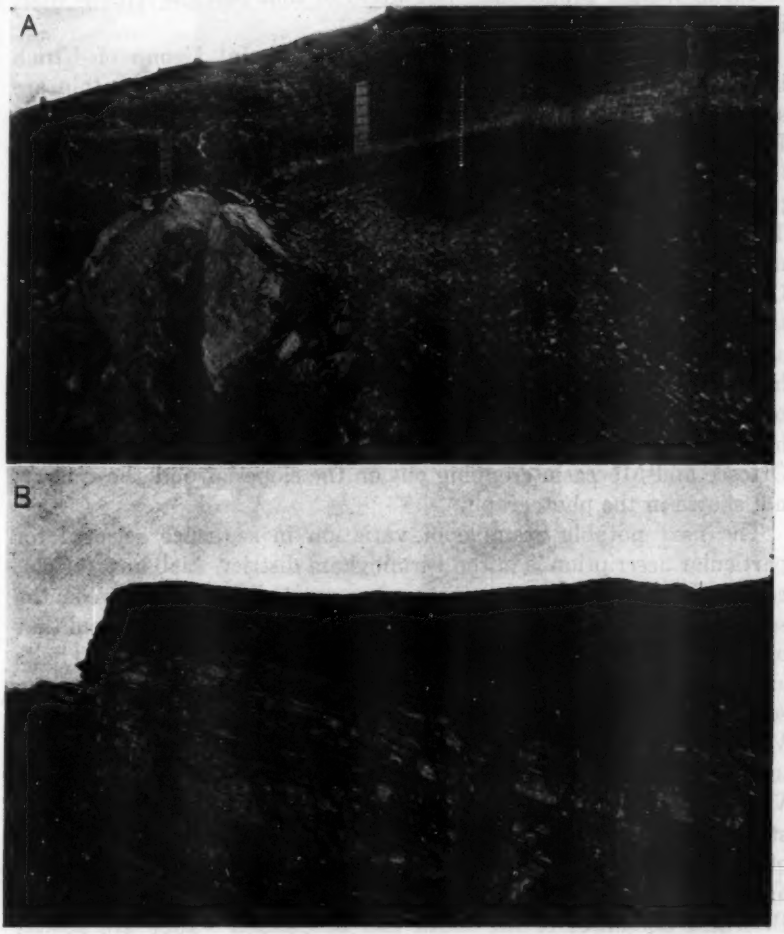

Figure 3.—A. Nodular Ottosee limestone unconformably overlying massive Holston limestone. The Athens shale, which normally follows the Holston, as shown in B, is absent. Highway cut on Little Indian Creek near the boundary between Russell and Tazewell counties, Va., looking southwest.

B. View of an abandoned quarry of the Mathieson Alkali Works, 2 miles southeast of Saltville, Va., looking east and showing the Athens shale immediately overlying the Holston limestone. The Ottosee limestone follows the Athens here, but its outcrop is hidden by the high ground above the quarry. This locality is southeast of Clinch Mountain and about 12 miles southeast across the strike from the locality of A.

of Little Walker Mountain. Southeast of that belt the Athens shale is the youngest formation present.

The differences in sequence within the Blount Group of Ulrich between the belts northwest and southeast of Clinch Mountain are shown on Figure 1, sections 3 and 4 and also in the photographs of Figure 3. In Figure 3A, the characteristic nodular limestone of the Ottosee is shown resting directly upon the thick bedded Holston limestone, the normally intervening Athens and Tellico being absent. This photo was taken on the road between Lebanon and Tazewell, near the line between Russell and Tazewell counties and northwest of Clinch Mountain. In Figure 3B the Athens is shown in contact with the Holston limestone near Saltville, southeast of Clinch Mountain, at the location 4 on the map, Figure 1. There is about 600 feet of Athens here, with characteristic Normanskill graptolites and other fossils peculiar to the graptolite zone. The Ottosee, 300 feet thick, is present here above the Athens and beneath the Moccasin limestone, both Ottosee and Moccasin cropping out on the slope beyond the quarry, not shown in the photograph.

The next notable example of variation in sequence selected for particular description is in the Birmingham district, Alabama. Here, as shown in Figure 4, there is a very great difference between the section in Cahaba Valley as shown in the right hand section from that of the Birmingham Valley shown on left hand section. The two belts are barely 8 miles apart across the strike and the distance from the southeast side of Cahaba Valley to the northwest side of Birmingham Valley is about 15 miles. The Conasauga limestone, 2,000 feet thick in Birmingham Valley, is not present on the northwest side of Cahaba Valley in the vicinity of Helena 14 miles south of Birmingham. Limestone and shale referred to the Conasauga are present in the south end of Cahaba Valley but, so far as known, it is of Middle Cambrian age and older than the Conasauga of Birmingham Valley. The Bibb and Brierfield dolomites of the south end of Cahaba Valley are absent farther north in that belt and also are absent from Birmingham Valley. The Ketona and Copper Ridge dolomites extend clear across both belts. The Chepultepec dolomite and Longview and Newala limestones, aggregating a thickness of 2,500 feet, occur only in Cahaba Valley, leaving a large erosional unconformity between the Copper Ridge dolomite and Chickamauga limestone of Birmingham Valley. The Longview is the same as the Nittany dolomite (*Lecanospira* zone) of Virginia and Pennsylvania, while the Newala includes the upper

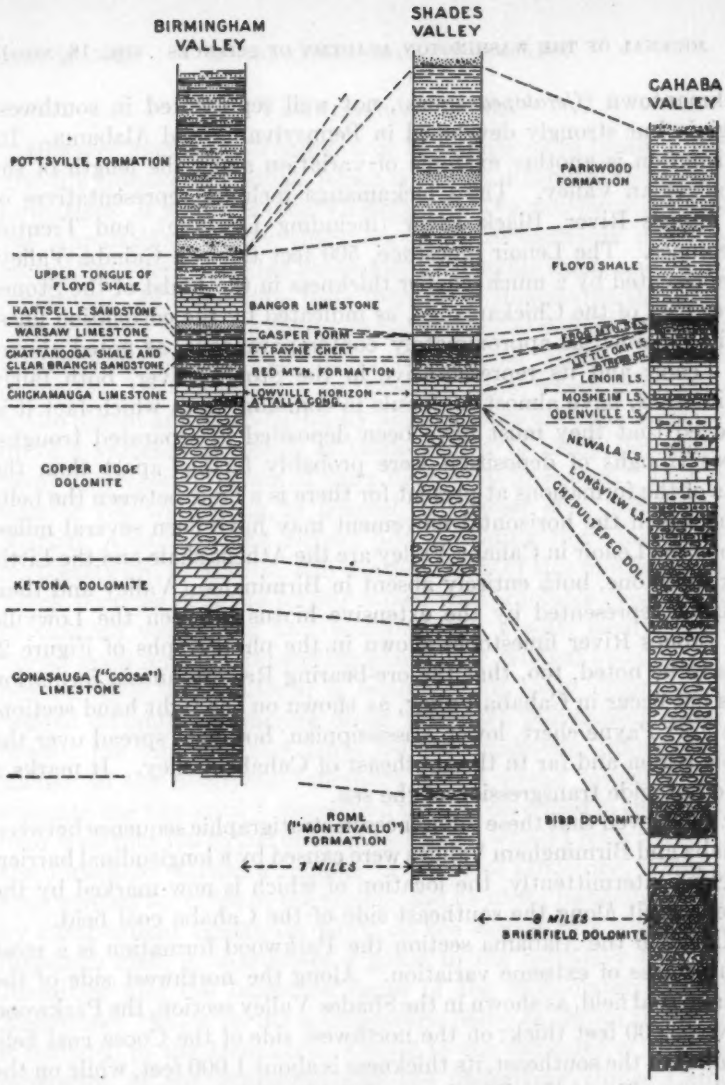

Figure 4.—Sections in the Birmingham District, Alabama, to show differences in sequence between Cahaba and Birmingham valleys. Reproduced from the Bessemer-Vandiver folio with change in the lower part of Cahaba Valley section. The formations below the Fort Payne chert are not exposed in Shades Valley but, except the Rome, crop out on the northwest of Red Mountain (which bounds Shades Valley on the northwest). They, and the Rome also, crop out southeast of the Cahaba coal field, which bounds Shades Valley on the southeast, so there is no reasonable doubt of their presence beneath Shades Valley. The part of the Cahaba Valley section from the Bibb dolomite down represents the sequence in the southern part of Cahaba Valley in the Montevallo region. In the part of Cahaba Valley beginning about 10 miles north of Montevallo and extending a considerable distance farther northeast, the Bibb and Brierfield dolomites, and the Conasauga limestone are absent and the Ketona underlies the Copper Ridge and rests upon the Rome formation. Scale, 1 inch = 2000 feet.

Beekmantown (*Ceratopea* zones), not well represented in southwest Virginia but strongly developed in Pennsylvania and Alabama. Its distribution is another example of variation along the length of the Appalachian Valley. The Chickamauga includes representatives of the Stones River, Black River (including Lowville), and Trenton limestones. The Lenoir limestone, 500 feet thick in Cahaba Valley, is represented by a much smaller thickness in the midst of the Stones River part of the Chickamauga, as indicated by the correlation lines. While regarded as approximately contemporaneous, as noted above, the Lenoir and its representative in the Stones River, both fairly fossiliferous, have almost no fossils in common, from which fact it is believed that they must have been deposited in separated troughs. These troughs of deposition were probably farther apart than the belts of the formations at present for there is a fault between the belts along which the horizontal movement may have been several miles. Above the Lenoir in Cahaba Valley are the Athens shale and the Little Oak limestone, both entirely absent in Birmingham Valley and their horizons represented by the extensive hiatus between the Lowville and Stones River limestones shown in the photographs of Figure 2. It is to be noted, too, that the ore-bearing Red Mountain formation does not occur in Cahaba Valley, as shown on the right hand section. The Fort Payne chert, lower Mississippian, however, spread over the whole region and far to the southeast of Cahaba Valley. It marks a period of wide transgression of the sea.

It is believed that these differences in stratigraphic sequence between Cahaba and Birmingham Valleys were caused by a longitudinal barrier, effective intermittently, the location of which is now marked by the Helena fault along the southeast side of the Cahaba coal field.

Higher in the Alabama section the Parkwood formation is a most notable case of extreme variation. Along the northwest side of the Cahaba coal field, as shown in the Shades Valley section, the Parkwood is over 2,000 feet thick; on the northwest side of the Coosa coal field 10 miles to the southeast, its thickness is about 1,000 feet, while on the southeast side of the Warrior coal field, northwest of Birmingham Valley, as exhibited in the Birmingham Valley section, the Parkwood and, it is believed, the Shades sandstone member and overlying shale, also of the basal coal measures (Pottsville formation) of the Cahaba field, aggregating a thickness of about 3,000 feet, are entirely absent. The northwest side of the Cahaba field and the southeast side of the Warrior field are now only 6 to 7 miles apart with a thrust fault between.

Variations in Facies

Honaker limestone.—Passing now to variations in facies, I take up first the Honaker limestone, which is mainly dolomite, and equivalent formations in southwestern Virginia. In the northwestern belts of the Appalachian Valley there are three recognizable divisions, in ascending order, Rutledge limestone, Rogersville shale, and Maryville limestone. In the middle belts there is no Rogersville shale and the corresponding rocks are nearly all heavy-bedded dolomite hardly to be distinguished lithologically from the Copper Ridge and Nittany dolomites. In the extreme southeastern belts, where the Rogersville is also absent and the Nolichucky not a distinct unit, the mass is made up of a variable succession of thick-bedded or shaly dolomite with many intercalated layers of pure light gray limestone. In a belt a mile or two wide lying, in general, northwest of a line connecting Marion, Abingdon, and Bristol and extending from the State line northeastward to Marion, still another facies of this unit is developed. Thick portions of it are largely mixed with insoluble clastic material so that on weathering and leaching only a soft, mealy, yellowish brown mass remains, preserving plainly the original bedding. Interbedded with such material is laminated or shaly dolomite; thick-bedded dolomite weathering down to a dark pulverulent mass; and toward the top relatively pure, banded, limestone, lithologically so similar to the overlying Jonesboro that I found myself unable to separate the two until I discovered that, as described in the Greenville folio, a section 100 to 200 or more feet thick, which I refer to the base of the Jonesboro, carries a number of layers of sandstone. This sandy zone persists for miles in the region, and as it can be easily recognized by its abundant sandstone debris on the surface of a predominantly limestone area, it constitutes a guide to the boundary between the Jonesboro and the limestone facies of the immediately underlying Nolichucky (which in the southeastern belts, as shown in Section 6, is included in the Honaker). Owing to the difficulty of making the separation of the Jonesboro and the underlying Upper Cambrian limestone, and owing to the fact that the Copper Ridge dolomite, at least in the usual facies that gives the characteristic expression of the Knox dolomite, did not exist in this broad belt between Bristol and Abingdon, the entire succession from the Rome ("Russell") formation to the Athens shale was, in the Bristol folio, thrown together as the Shenandoah limestone. Within this mass it is possible to discriminate: first, the *Honaker* limestone, or perhaps a new unit which will include

the Honaker and the limestone equivalent of the Nolichucky shale; second, the Jonesboro limestone; third, the Nittany dolomite, overlain by a thin representative of the post-Nittany *Ceratopea* zone; fourth, the Mosheim limestone; and fifth, the Lenoir limestone.

Jonesboro limestone.—As I have already pointed out, the Jonesboro limestone may be in part a limestone facies of the Copper Ridge dolomite—that is a question that may be definitely decided in the future. Trilobites occur in the lower part of the Jonesboro and will afford an answer if ever found in a matrix from which they can be extracted. The facts next to be presented may have a bearing upon the formation of opinion in the matter.

On the northwest side of the Valley from Pennsylvania to Alabama, the Beekmantown formations (Canadian of Ulrich) are, with the exception of the Stonehenge and Axemann limestones in Pennsylvania, all dolomite. Along the southeast side of the Valley the corresponding formations are nearly all limestone. In Center County, Pennsylvania, the Beekmantown formations are 4000 feet thick, all dolomite except 650 feet of Stonehenge at bottom and 100 to 200 feet of Axemann limestone in the midst. In the Mercersburg-Chambersburg area, Pennsylvania, a belt which, across the strike, is 40 miles southeast of the Center County area, the Beekmantown is described by Stose as limestone. In Tuckaleeche Cove, on the extreme southeast side of the Appalachian Valley southeast of Knoxville, Tennessee, are deposits of Beekmantown age according to Ulrich, which, according to both Keith and Ulrich, are also limestone. The same is true in Alabama where, in Cahaba Valley, southeast of Birmingham and along that strike into Georgia, rocks of Beekmantown age are predominantly a very pure limestone above and include a large proportion of limestone in the lower 500 feet (the Longview limestone or *Lecanospira* zone). There seems thus to be a decided tendency for the Beekmantown rocks to consist of limestone to the southeast and dolomite to the northwest. It would be in accordance with this tendency for the Jonesboro limestone to be in part a southeastern facies of the Copper Ridge dolomite. On the other hand, the Jonesboro is a lithologic unit, the upper 500 feet of which at least seem to be clearly of Beekmantown age and Ulrich thinks it very probably is all Beekmantown.

Athens shale.—Another striking example of facies differences is found in the Athens shale. In the middle belts of the Valley from Lexington, Virginia, to Marion, Virginia, the Athens is composed largely of thin-bedded, dark limestone and of black shale in varying proportion. At Lexington practically the whole thickness is lime-

stone, which has been named the Liberty Hall limestone. At Marion and in the vicinity of Wytheville there is an alternating succession of beds of shale and limestone. In great contrast with the limestone facies is a sandstone facies in the belts along the southeast side of the Valley in the Wytheville-Bristol region. The Athens here includes black shale several hundred or perhaps 1000 feet thick at bottom and an unknown but great thickness of thick-bedded, coarse-grained, loosely cemented, arkosic sandstone above. This sandstone facies extends to the top of the Athens throughout these southeastern belts, no younger beds being present. The total thickness of the sandstone and of the entire Athens in these belts is therefore unknown but, from the great width of the area, which southeast of Bristol is about five miles, and the steep dips, one gets the impression of a very great thickness—several thousand feet at least. The sandstone in the Athens has been mapped here as Tellico, but its Athens (Normanskill) age is proven by characteristic genera and species of graptolites occurring in the shale partings high up in the sandstone part of the formation.

An interesting fact is disclosed by the distribution of the sandstone and limestone facies of the Athens. A narrow syncline immediately southwest of Wytheville occupied by the sandstone facies, is exactly like the synclinal belts southeast of Bristol and Abingdon. Not a layer of limestone is present in a thickness of a thousand feet or more in this strip. On the other hand, at Marion, in a small fenster, 2 to 3 miles east of Wytheville, and in Crockett Cove about 4 miles north of Wytheville, the limestone facies of the Athens is well developed and contains not a layer of sandstone. This apparent anomaly, namely the presence of the sandstone facies of the Athens southwest of Wytheville lying directly in the strike between the limestone facies at Marion and that of the fenster 2 miles east of Wytheville, is explained by the fact that the elongated area west of Wytheville has been shoved several miles northwest from its position at the time of deposition by the movement on the great Pulaski fault. It belongs in the strike of the belts southeast of Bristol and Abingdon, while the areas of the limestone facies are in their normal places. They belong to the part of the crust beneath the Pulaski thrust that has not been displaced.

Lowville, Moccasin, and Bays formations.—The next example of facies difference is the Lowville-Moccasin-Bays unit. On the northwest side of the Valley from Pennsylvania to Alabama and west over the Nashville Basin, only the typical Lowville blue or dove limestone

facies occurs. In places as along the northwestern slope of Wallen Ridge in southwestern Virginia, however, layers of greenish, argillaceous crumbling limestone or calcareous mudrock occur in the formation. This mudrock is lithologically identical with such rock in the Moccasin facies except that the latter is red. In the middle belts of the Valley in southwestern Virginia, as shown in sections 3, 4, and 5, Figure 1, and through Tennessee and northwestern Georgia to the northern part of Cahaba Valley, Alabama, the Lowville is represented by the Moccasin limestone, distinguished by the red shale, or mudrock, and the red argillaceous limestone, which make the bulk of the formation. In northwestern Georgia, as at Rocky Face, a few miles northwest of Dalton, a formation of red mudrock estimated to be as much as 1000 feet thick is believed to be the representative of Moccasin. In northeastern Alabama, in Colvin and Beaver Creek Mountains, between Calhoun and Etowah counties, and in St. Clair County, extending southwest to Odenville and in strike with the area at Rocky Face this lithology, although not so thick as at Rocky Face, is changed still more by the introduction of fossiliferous sandstone. In eastern Tennessee, along the southeastern side of the Valley, the beds of Lowville age also carry much sandstone as well as red shale and some limestone. This is the Bays facies, the formation in these southeastern belts being named the Bays sandstone. That these regional developments are but different expressions of contemporaneous deposition is proved by the all but universal occurrence of the Lowville guide fossils somewhere in the mass in all these areas except that at Rocky Face, where if present, they have not yet been discovered. In all areas of the Moccasin and Bays facies in Virginia, gray limestone in the lower part of the formation contains either *Tetradium cellulosum* or *Cryptophragmus antiquatus*, or both. In northeastern Alabama *Tetradium cellulosum* has been found in limestone at both top and bottom of the formation, and characteristic Lowville species of ostracods also occur. In contrast to the clastic or impure limestone (Moccasin or Bays) facies of the southeastern or middle belts, the Lowville of the northwestern side of the Valley is in large part very pure. Twenty-one samples from the quarries at Bellefonte, Center County, Pennsylvania, show an average content of about 97 per cent calcium carbonate, 1 per cent magnesium carbonate, and 2 per cent insoluble matter.

Like the Lowville, the next overlying limestone, of Trenton age, is, in the northwestern belts and in the Cincinnati and Nashville regions,

a relatively pure limestone, easily enough recognized as a distinct group of minor units by its lithology and fossils. In the middle belts of the Valley, and in Pennsylvania also in the country to the southeast of the Valley proper, the Trenton, as determined by its fossils, is represented by the lower part of the Martinsburg shale, as shown in sections 3 to 5, Figure 1.

Formations of Richmond age.—If identifications of fossils and correlations of formations are correct, one of the most noteworthy examples of facies differences is found in the Medina group of the New York classification and its equivalents elsewhere. In Pennsylvania the Juniata formation is non-marine red shale and red sandstone. In southwestern Virginia it is red shale with layers of impure limestone carrying marine fossils, the Sequatchie formation. On the escarpment south of Lake Ontario its equivalent is the red Queenston shale. Going from Queenston through Ontario, Canada, to the northern end of Lake Huron and thence southward into southeastern Indiana, this non-marine red shale of Pennsylvania and New York can be traced step by step into the highly fossiliferous limestone of the Richmond group of southern Indiana and southwestern Ohio. From Indiana and southwestern Ohio, the Richmond, still fossiliferous, can be traced into northwestern Alabama and unmistakably identified in Sequatchie and Big Wills Valleys in Tennessee and Alabama, where, however, red color begins to appear in the argillaceous limestone. From Big Wills Valley it can be traced far into Tennessee and probably into southwestern Virginia where, as noted above, the unit is red shale with layers of impure limestone. The upper part of the old Medina group, now named Albion sandstone, so fully displayed in the Niagara gorge and containing in its lower part a few marine fossils, is almost certainly the same as the non-marine Tuscarora quartzite of Pennsylvania and the Clinch sandstone of Virginia. The stratigraphic position of the Albion, Tuscarora, and Clinch is identical—between the Queenston-Juniata-Sequatchie below and the Clinton above. Northwestward through Ontario the Albion, in part at least, is the same as the fossiliferous, partly limestone Cataract formation, and this in turn is correlated through its fossils with the fossiliferous marine Brassfield limestone of Ohio and Kentucky. The Brassfield through its fossils is identified by Ulrich with part of the iron ore-bearing Rockwood formation at Rockwood, Tennessee, and at Jasper, Sequatchie Valley, Tennessee, and with the part of the Red Mountain formation of Alabama below the "Big Seam" of iron ore. The part of the Red Mountain formation overlying and including the "Big Seam"

is of Clinton age. At Cumberland Gap, Virginia-Tennessee, the Brassfield fauna is found in beds that are limy at the top and gritty at the bottom and which, like the Clinch sandstone of Virginia and the Tuscarora quartzite of Pennsylvania, lie between the Clinton above and the Sequatchie or Juniata below. There seems no considerable doubt that the Albion, Cataract, Brassfield, Clinch, and Tuscarora are all different facies and names for essentially one time unit.

Mississippian formation.—As a last example of facies change, I will mention that which takes place in the Mississippian formations of southwestern Virginia. At Cumberland Gap the Keokuk and St. Louis are very thinly represented and the intervening Warsaw is absent. All the other Mississippian formations at Cumberland Gap are relatively thin, aggregating barely 1000 feet. In the trough southeast of Clinch Mountain (Figure 1, section 3), the Keokuk is absent, but the Warsaw and St. Louis are well represented and the total thickness of the Mississippian is around 6000 feet. It is one of the thickest Mississippian sections known. Except for the Price and Pennington formations, which are clastic in both regions, there is a marked difference in composition of the formations in the two regions. The change in thickness and composition is particularly striking in the Ste. Genevieve and Gasper formations. At Cumberland Gap they are composed of thick-bedded oolitic limestone of high purity and their combined thickness is about 200 feet. Southeast of Clinch Mountain, on the other hand, these formations are predominantly highly argillaceous, thinly laminated limestone which weathers to a soft material much like a shale and their thickness is over 2300 feet as against 200 feet at Cumberland Gap. This difference is probably due to the proximity of the southeastern area to the sources of the clastic sediment which is mixed with the calcareous constituents of the formation.

Conclusions

The most important conclusion to be drawn from the distribution of the various formational units of the Appalachian Valley is that the Appalachian Geosyncline and a great area to the west were in a state of intermittent warping. At a given time one part was above water and another part below. At a later time the conditions were reversed. Sometimes, as in Nittany and Lowville times, submergence was certainly widespread if not universal; at other times, as in the time when the Tellico sandstone was laid down in the Knoxville region, emergence prevailed Through all of upper Chazy ("Blount"), time the dis-

tribution of formations and faunas indicate that the middle part of the Valley in the Virginia-Tennessee region, especially on the southeast side, was depressed while the north and south ends, and especially the northwest side, were elevated. This elevation also affected a great area extending far to the westward over the present sites of the Nashville and Cincinnati domes, where deposits equivalent to Ulrich's Blount group are unknown and where the Carters limestone, equivalent to the Lowville limestone, rests upon the Stones River limestone with so strong an appearance of conformity that Ulrich was for a long time puzzled as to their relations, in fact, until he had discovered the existence of the beds which he called the Blount group intervening in time between them and had established the Lowville age of the Carters through its fossils.

Contemporaneous local warping occurred and controlled the distribution of the members of the group itself. First the deposition of the Holston limestone extended westward for 10 miles or more beyond the northwest limit of the Athens shale. Emergence of the trough progressed, as proved by the restricted distribution of the Athens toward the northwest as compared with that of the Holston, though the apparent shrinkage was possibly of the nature of an uplift in the northwest and depression in the southeast side of the trough, causing a southeastward shift of the trough in Athens time. But emergence and shrinkage of the area of deposition continued some time, as attested by the small area of the Tellico as compared with that of the Athens or Holston. After Tellico time, however, a downward warping set in, as witnessed by the northwestward extension of the Ottosee limestone beyond the limits of the earlier Holston. This movement continued until in the succeeding Lowville-Moccasin-Bays time the entire geosyncline and the area westward beyond the present location of the Mississippi River, where the Lowville is represented in the Plattin limestone of Arkansas and Missouri, was submerged.

As to the matter of barriers—in only one case does a relatively narrow longitudinal barrier separating two troughs within the geosyncline seem to be needed to explain the facts. I refer to the apparently contemporaneous Lenoir limestone and the Ridley limestone of the Stones River group. In Alabama these two formations occur within less than 10 miles of each other across the strike. Both are fossiliferous, yet so far as known, there are no species, or at most only very few, in common and these were of cosmopolitan oceanic distribution.

The Lenoir fauna is of Atlantic origin and has closer affinity with the Ordovician faunas of Scotland and Scandinavia than with the fauna of the Ridley, 10 miles away, which on the other hand, carries a fauna of the interior Nashville basin. However, as there is a great overthrust between the two areas, the Lenoir was doubtless deposited at a distance from the Ridley greater than that by which they are now separated. At that, however, it is difficult to understand how animals with free swimming larvae and other means of distribution did not commingle if there were open water connections between the areas in which they lived or, in other words, if they had been deposited in the same sea.

Finally, it seems to me that these variations in stratigraphy, of which a few examples have been given, are a record of a constantly and gently oscillating crust or exterior shell of the earth which caused a continual shifting of the areas of land and sea within the Appalachian geosyncline throughout Paleozoic time. That the oscillations or pulsations were gentle is proved by the absence, throughout the entire Paleozoic sequence of the Appalachian Valley, of strong angular unconformities between deposits separated by long periods of time, the physical relations between such deposits, as revealed within the limits of actual exposures, very closely simulating continuity of deposition even where the breaks are greatest. See the photographs of Figure 2. As a matter of fact, it is only through tracing certainly identifiable formations over large areas and finding that they become separated by thick intervening deposits absent at the place of starting, or through the determination of the age of contiguous formations or contiguous parts of a seeming lithologic unit by means of fossils, that the existence of many great stratigraphic gaps or unconformities can be detected at all. The causes of the earth movements involved in these geologic phenomena are a fascinating and tantalizing subject of speculation but their investigation falls within the province of the geophysicists.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

394TH MEETING

The 394th regular meeting was held June 2, 1927, in Room 43 of the National Museum. In absence of the president, the corresponding secretary-treasurer presided. The entire evening was devoted to brief notes and exhibition of specimens.

Dr. T. E. SNYDER spoke of the genus *Coptotermes* which was established in 1896 by Wasmann, the oriental species *gastroi* Wasmann being the genotype. There are approximately 43 species, 21 oriental, 9 Australian, 9 Ethiopian, and 4 neo-tropical. The status of some of the species is as yet in doubt. The genus *Coptotermes* is in the family Rhinotermitidae, the intermediate family between the higher and lower termites. Most of these termites are subterranean in habit; a few of them make hard carton true nests, but most of them burrow in soil and wood with diffused nests. Soldiers of species of *Coptotermes* have a frontal gland which exudes an acidulous secretion coagulating and hardening in the air which is used as defense against ants. With this secretion it is possible to dissolve lime mortar in stone and brick foundations. The Japanese Government has prohibited the use of lime mortar in consequence. Species of *Coptotermes* attack buildings, bridges, telephone poles, and various growing crops. They are a serious enemy in rubber plantations. About 1913 a *Coptotermes*, at first supposed to be the Australian species *C. lacteus* Froggatt, was discovered on the Island of Oahu at Honolulu. In 1920 the Japanese entomologist, M. Oshima, described it as a new species, *C. introdens*, close to but distinct from *C. formosanus* Shiraki. In 1924 it was found on the Island of Hawaii at Hilo. In 1926 American entomologists decided that *intrudens* is a synonym of *formosanus* of southern Japan, Formosa and the south China coast. Another species of *Coptotermes*, a new species doing 95 per cent of the damage to buildings done in the Philippines, was intercepted in Hawaii and has not become established. Owing to the fact that *Coptotermes formosanus* has been found infesting floating dry docks, coal barges, and other vessels in the harbors of the Hawaiian Islands, it is quite possible that it may be introduced into continental United States, especially California. Every effort will be made by the Federal Horticultural Board, the State Board of Agriculture of California, and officials at Hawaii, to prevent this. The insect builds a concentrated nest, hence fumigation is an effective control measure. A photograph was shown of such a nest found in the hold of a floating dry dock from which nest earthlike shelter tubes went down on timbers below the water level, i.e., were submerged in salt water. This ability of the insect to live below the water line is a strong point in its life history.

Dr. SNYDER also discussed *Insect damage to yellow and white pine timbers in the roof of the White House.* During May 1927 an examination was made of the timbers from the roof of the White House which were being removed in repair work. The supporting timber trusses had been pulled out of place so that they no longer structurally served as trusses but carried the heavy load as beams. This caused the roof to sag to a dangerous degree. It was found that the white and yellow pine timbers had become infested by *Hexarthrum ulkei* Horn, one of the Cossind beetles in the family of weevils Curculionidae.

This insect is one of the so-called powder-post beetles which reduce the wood fiber to a powder-like condition. There are several earlier records of similar damage to the woodwork of buildings and flooring, caused by this insect, some of these records occurring in Washington, D. C. The ends of heavy timbers were badly weakened where they had been eaten by these insects—some were even broken off. The insect also invaded sound lathing attached to the infested timbers. There was no decay in some of the timbers infested by this beetle nor in the lathing. However, decay was present in the ends of some of the timbers supporting the roof of the tall portico in front of the White House. These powder-post beetles usually lay their eggs in joists or crevices of timber under conditions of darkness and poor ventilation. Impregnation treatments of timbers with zinc chloride would prevent such infestation and even coats of varnish would probably be effective. Frequent inspection of untreated timbers is advisable, especially in old buildings. Where timbers are not structurally weakened the insects infesting them can be killed by thoroughly saturating the wood with orthodichlorobenzene, applying the liquid with a saturated rag or mop, or as a spray. Several applications may be necessary to kill the insects. If this chemical is used as a spray it is advisable to open the building, as the odor of the chemical may prove disagreeable in a closed room. In spraying timbers overhead, care should be taken not to let the liquid drip down as it might slightly burn the face and hands and would be especially injurious to the eyes.

Dr. H. MORRISON discussed briefly the Cockerell types of Coccidae in the U. S. National Museum. According to most recent lists there are now over 3000 described species of Coccidae, of which 512, or approximately one sixth, have been described by Dr. Cockerell. The National Collection of Coccidae, according to a preliminary check, contains types or co-types of all but 81 of the species described by Dr. Cockerell. Mr. ROHWER spoke briefly of Dr. Cockerell's 19-month fossil collecting trip now in progress.

Dr. MORRISON also reported arrival of two shipments of scale insects sent for identification over a year ago by Mr. Kincaid from Seattle, Washington. These proved to be *Lecanium coryli* (Linn.), a species reported once from Nova Scotia many years ago, though there is no certainty that the identification was correct. It was introduced some 15 years ago into British Columbia and has recently attained importance as a pest of shade trees. It is a general feeder on shade, ornamental and rosaceous fruit trees, and occurs in considerable numbers in Stanley Park, Vancouver, and in Seattle and adjacent territory. Some efforts have been made to obtain an appropriation from Congress for work on it. Material was exhibited by Dr. MORRISON.

Dr. SCHAUSS reported the recent gift by Jordan of a paratype of *Sthenauge parasitus* Jord. He discussed briefly its larval habits, especially its rather curious feeding habits. He also read a paragraph from Novitates Zoologicae (vol. 33, 1926) containing additional very interesting information regarding it.

Mr. BARBER exhibited local forms of Lampyridae and spoke of the contrast between "species" as they have been recognized by taxonomic study and "species" as they occur in nature. He thinks of a species as a living population, reproducing its kind, but isolated from other species by specialized habits or adaptations. These may be evident in distinctive mating instincts, in peculiar ecological habitat, in time of appearance, etc., as well as (more fortunately from our standpoint) in differences in structure. The Lampyridae differ from their near relatives the Lycidae and the Cantharidae (Tele-

phoridae) in the almost universal persistence of the photogenic function which so far as known remains in the larval stages of even those forms whose adults have lost their lights by becoming diurnal in their activities. Those retaining their crepuscular or nocturnal flight period have modified the photogenic organs for use in courtship signals, and the light emissions have become so distinctive in species maturing concurrently as to constitute a barrier against hybridization. About 30 species have been found in the vicinity of Washington but the taxonomy of the group is so confused that but few can be identified. The differential characters are usually not recorded in descriptions, most of the types are inaccessible, the recorded synonymy is based almost entirely on opinions formed from superficial resemblances of poorly preserved and unauthentic samples. Of the 69 species of the family listed from the United States in the Leng Catalogue about 14 appear to be known from the vicinity of Washington but this number will rise to more than the 30 species thus far encountered when the incorrectly suppressed species, and the new forms are untangled and elucidated.

Mr. BARBER cited *Phanaeus carnifex* as an example of specific misidentification which has been so consistently overlooked that almost 170 years have passed without a single correct application of this name to the species described in Linnaeus' 10th edition. He exhibited specimens of the three well-known species confused by Linnaeus under the name *Scarabaeus carnifex* and showed that the original description was probably not based upon specimens but upon two figures. One of the latter is the Jamaican species well known as *sulcatus* Drury 1770, the other became *Scarabaeus festivus* Linn. 1767. On the latter date Linnaeus applied the name *carnifex* to our well-known tumblebug of the Atlantic Coast. The three species involved being merely collectors' prizes, the name not as yet entering economic, medical, or popular literature, the case seems one for simple adjustment in conformity with nomenclatorial rules rather than for recourse to the International Commission on Zoological Nomenclature which has plenary power and might set the rules aside to validate the established usage in this case. Thus *carnifex* Linn. 1758 would suppress *sulcatus* Drury 1770 (a coal-black species from Jamaica), *carnifex* Linn. 1767 (being a homonym) would be rejected in the synonymy of the next available name, and our brilliant Carolinian species would be known henceforth as *vindex* Macleay 1819, while the glorious red Venezuelan *Oxysternon festivum* (Linn. 1767) remains unchanged.

C. T. GREENE spoke of two species of Diptera which were external parasites on aquatic hosts. He exhibited two pamphlets as follows: (1) "The Larva of a Chironomid (*Trissocladius equitans* n. sp.) which is parasitic upon a May-fly Nymph (*Rithrogena* sp.)" by P. W. Claassen. The larval and pupal stages of this fly are passed under the wingpads of the host. (2) "Le Cycle Évolutif de *Dactylocladius commensalis* sp. nov. Chironomide à larve commensale d'une larve de Blepharoceride (Diptera)" by A. Tonnoi. This larval parasite lives on the under side of the Blepharocerid larva passing both the larval and pupal stage there.

Dr. MANN narrated an incident of one of his collecting trips some time ago in Honduras in which his curiosity had been considerably aroused by rumours of a mysterious tree called by the natives the "rain-tree," and which he supposed would prove to be one bearing some form of Cercopid drip. When at last he had opportunity, however, to examine the tree he found that there indeed came from it tiny spurts of water as reported, but instead of Cercopids being the cause of this he found the trouble was caused by an infestation in

considerable numbers by a large species of *Cicada*, specimens of which he duly collected for the National Museum.

Dr. G. F. WHITE reported briefly on studies he is making on a protozoan (*sporozoan*) and a bacterial disease of the Mediterranean flour moth (*Ephestia Kuehniella* Zeller). The protozoan disease is particularly infectious in cultures of this insect and has proven to be a very troublesome factor to different workers using this species in their studies. Infection takes place through the food ingested. Death may occur at any stage of the insect following infection. The disease is not limited to *Ephestia*. A bacterial disease of this species was first described in Germany and its causal organism determined and named. This infection has been encountered in cultures of the insect in Washington. Death takes place during the larval stage, the mortality sometimes reaching 100 per cent. The possible use of these maladies in the control of this insect pest was suggested. A further discussion of these diseases will be given at a later time.

Mr. ROHWER called attention to a circular letter which was being distributed by Dr. C. W. STILES asking for the opinion of American zoologists regarding the objections of Dr. Franz Poche, of Vienna, to certain rules and procedures of the Commission on Zoological Nomenclature. Dr. Poche has circulated a letter requesting zoologists to petition the Commission to make certain radical changes in the Code, and also to make a radical change in the method of handling matters of nomenclature. These circular letters by Dr. Poche have received the approval of a great many zoologists, but some of them have probably not had sufficient opportunity to study the question from all angles. Hence Dr. STILES has felt it desirable to bring the matter to the attention of the American zoologists. In discussing Dr. STILES' circular letter, Mr. ROHWER touched briefly on two of Dr. Poche's propositions. The first proposes that problems of nomenclature be brought before the General Congress for discussion by a majority vote of members of the Commission instead of by a unanimous vote. He stated that this would not be fair to the countries which have only one representative on the Commission, as sometimes this representative cannot be reached promptly and a matter might be presented to the General Congress without his having even considered it. Another objection to the majority vote is that the attendance at the meetings of the General Congress is always predominantly from the country in which the meetings are held; therefore if a proposition should be presented without the unanimous approval of the Commission, it is fairly certain that the ideas of the country in which the meetings are being held would prevail. This is obviously unfair to the other countries, and would destroy the international unity which now prevails in settling nomenclatural problems. The second proposition of Poche discussed by Mr. ROHWER deals with the reversion to the principle of elimination in fixing genotypes. Mr. ROHWER pointed out that a controversy had taken place a number of years ago between the school which advocated the fixation of types by the elimination principle and those who wished to adopt the first species rule. A compromise was reached in which both methods were adopted, and in addition the principle of priority was introduced and certain machinery for the selection of genotypes was set up by the International Commission in Article 30. The adoption of Poche's proposition of fixing genotypes only by the method of elimination would break faith with those people who agreed to the compromise which was reached in 1907, and would create chaos, inasmuch as it would set aside many designations which have been made on the recommendations of Article 30.

Mr. ROHWER stated that the Committee on Nomenclature of the Society had already replied to Dr. Stiles' circular, and as individuals had opposed all of the propositions advanced by Dr. Poche. He urged each member of the Society to study the matter carefully and to sign the circular submitted by Dr. STILES so that he could have a complete record of the opinions of American biologists.

395TH MEETING

The 395th regular meeting was held October 6, 1927, in Room 43 of the National Museum. President J. A. HYSLOP presided.

In commenting on the minutes of the previous meeting, Dr. HOWARD stated that he had recently met in Prague a Mr. C. Blattney who informed him that *Lecanium coryli* (Linn.) and *L. cornei* were very heavily parasitized there, and that he would be glad to furnish us with material if needed here.

The Corresponding Secretary-Treasurer read a letter from the Honorary President, Dr. E. A. SCHWARZ, presenting to him for the society one thousand dollars in securities of the American Building Association of this city, the income of which is to be used year by year to augment the printing fund. An enthusiastic and unanimous vote of thanks was tendered to Dr. SCHWARZ for this gift, the characteristic generosity and thoughtfulness of which are very deeply appreciated by every member.

Dr. S. B. FRACKER, formerly of Madison, Wisconsin, now of this city, was elected to membership. Upon request, Dr. FRACKER made a few remarks and discussed briefly the lack of opportunity for research in administrative work.

Greetings and felicitations were extended to Dr. HOWARD upon his safe return from Europe. He will discuss his recent trip in some detail at a later meeting.

Mr. GREEN reported the death of Mr. H. S. HARBECK at Philadelphia, October 2. Mr. HARBECK's interest had been in collecting Diptera.

Program: F. L. CAMPBELL: *The toxicology of arsenic as an insecticide.* Methods and apparatus for the determination of acute and chronic minimum lethal doses of arsenic for individual insects were described. The M. L. D. of arsenic for insects from the data now available appears to range from 0.003 to 0.03 mg. of arsenic per gram of insect, the dose varying with the species of insect, its age, and the compound of arsenic employed. The M. L. D. of arsenic for insects and mammals is of the same order of magnitude.

Discussed by MCINDOO, HOWARD, RICHARDSON and BRIDWELL.

Dr. W. H. LARRIMER: *Results of the ten-million-dollar European corn borer campaign.* A summary of the results of the campaign and opinions thereon were given under three subdivisions: (1) *United States Department of Agriculture:* Surveys of 743 townships in the heavily-infested states indicate that the ten-million-dollar spring campaign against the European corn borer has retarded the insect's rate of increase. Census of the borer population, as determined by actual count in the field during the past two months in Michigan, Ohio, New York, and Pennsylvania, shows that there is now an average of fourteen borers per one hundred stalks in the campaign area, as compared with an average of nine borers per one hundred stalks last year. In 1925 the borer population in the area was two borers per one hundred stalks. Though this means an increase of fifty percent in borer population this year, it compares favorably with the increase of over three hundred percent in borer population registered in 1926 when there was no control campaign. Had

there been no campaign this spring, judging by the increase in 1926, we might now find about thirty-two instead of fourteen borers per one hundred stalks. The increase from nine to fourteen borers per one hundred stalks came this year despite a clean-up that destroyed ninety-five percent of the borers. Five borers left of an original population of one hundred will produce on an average one hundred fifty mature borers. The clean-up this spring was even more effective than the Department had expected. (2) *Executive Committee of the International Corn Borer Organization:* After due consideration of the data presented, and after observing conditions, it is the judgment of the Committee that the campaign has been successful as far as humanly possible. (3) *Joint Committee of the American Association of Economic Entomologists, the American Society of Agronomy, and the American Society of Agricultural Engineers:* The committee of entomologists, agronomists, and agricultural engineers cooperating, endorse the efforts to control the corn borer and commend those engaged in directing the research, regulatory and extension activities designed for its control. Especial commendation is given to the multitude of farmers who cooperated in the clean-up campaign. It is believed that the compulsory clean-up of 1927 not only greatly reduced the rate of infestation increase, but has been successful in preventing serious commercial losses, and that the expenditure of large funds for this purpose has been completely justified.

Discussed by WEBB, MCINDOO, HOWARD, HYSLOP, BISHOP and MORRISON.

Mr. ROHWER discussed the recent generous gift by will of the late Dr. C. F. BAKER to the U. S. National Museum of his insect collection, and of Mr. CUSHMAN'S trip to the Philippines to procure it. He gave a brief outline of Dr. BAKER'S career, and spoke appreciatively of his arduous labors in the advancement of entomology. This gift is a very notable addition to our national collection, and doubtless will be worked over by investigators for many years to come. A committee, consisting of HOWARD, GRAF and ROHWER, was appointed to draw up appropriate notice of Dr. BAKER'S death.

396TH MEETING

The 396th regular meeting was held November 3, 1927, in Room 43 of the National Museum. President J. A. HYSLOP presided.

Dr. F. L. CAMPBELL, Mr. H. H. SHEPARD and Mr. R. S. FILMER were elected to membership.

Resolutions regarding the death of Dr. C. F. BAKER were read by Dr. HOWARD, and incorporated into the minutes as follows: "The Entomological Society of Washington, by formal and unanimous action, not only expresses its great sorrow on learning of the death of its long-time member, CARL F. BAKER, but here records its very high esteem for the man and its admiration of the very wonderful work that he accomplished in his comparatively short life. The Society considers that his life efforts to increase our knowledge of insects have been of the very greatest importance to science, and believes that his achievements are almost unparalleled in the history of entomology. The Society is deeply gratified to know that Dean Baker held Washington entomologists in such high esteem that in his will he arranged to have his extraordinary collections in entomology brought to Washington and deposited in the U. S. National Museum." It was recommended that copies of this minute be sent to the family of Dean BAKER.

Dr. STANISLOW MINKIEWICZ of Pulawy, Poland, gave a brief summary of his tour the past summer over various parts of the United States and Canada. During this trip he was able to visit and review entomological work at Ithaca and Geneva, New York; portions of Canada and Nova Scotia; Melrose Highlands and Arlington, Massachusetts; Riverton, New Jersey; Columbus and Wooster, Ohio; West Lafayette, Indiana; Urbana, Illinois; Manhattan, Kansas; Salt Lake City, Utah; various places in central and southern California; Portland, Oregon; Seattle, Washington; Vancouver, British Columbia; Madison, Wisconsin; and East Lansing, Michigan. He also touched briefly on some of the agricultural and entomological problems in Europe, and contrasted conditions there with those in this country, dwelling especially on the lack of parasites here for control of the imported injurious insects. He expressed his thanks to Washington entomologists for courtesies extended to him.

Dr. H. T. FERNALD, Massachusetts Agricultural College, Amherst, Mass., discussed the value of professional contacts offered by the entomological organization in Washington and deplored the comparative isolation in which many entomologists like himself were obliged to work.

Prof. R. A. COOLEY, Agricultural Experiment Station, Bozeman, Montana, discussed a parasite (*Ixodiphagus texanus* Howard) of the spotted-fever tick.

Dr. C. F. DOUCETTE, of Santa Cruz, California, described some recent bulb work on the West Coast.

Mr. C. H. HADLEY, of Toledo, Ohio, and Dr. F. W. Poos, of the Norfolk (Va.) Truck Experiment Station, also spoke briefly.

The first address on the regular program was given by Dr. HOWARD, who, with the help of lantern slides, told about some of the entomological highlights of his summer in Europe. During the trip he visited England, France, Germany, Poland, Czechoslovakia, Austria, Hungary and Jugoslavia. He showed portraits of a number of entomologists known to the members of the Society by reputation but who never have been in this country. Excellent work is being done at the newly instituted parasite laboratory of the Imperial Bureau of Entomology at Farnham Royal, England, by S. A. Neave, J. F. Myers and R. Stenton, and also at the Biologischen Reichs-Anstalt, in Berlin, under Dr. A. Haase. Active work is being carried on in Poland and Czechoslovakia. An exact description of the entomological material which has been brought together in great quantity by Dr. J. Obenberger in the National Museum at Prague since the conclusion of the great war had been placed in Mr. Rohwer's hands by the speaker. Two young Russian refugees, S. Novicki at Skierniewice, Poland, and L. Oglobin at the Prague Museum, are intensely interested in the parasitic Hymenoptera. A brief account of the Tenth International Zoological Congress at Budapest the first week in September was given, illustrated by portraits of most of the entomologists in attendance, including especially striking pictures of Dr. S. Bodenheimer of Palestine and Dr. L. Biro of Budapest.

Dr. E. A. BACK: *Some facts regarding moth proofing solutions.* The speaker renewed the investigations to date, and by means of lantern slides and actual samples of injured materials brought out details of much interest. Tests made in the Bureau of Entomology indicate that no solution now on the market will permanently and absolutely protect fabrics from attack by fabric pests, though it appears to be true that the better solutions when applied properly do impart a protection that is worth considering. Solutions that impart a real degree of resistance to moth attack when properly applied

have been found to be worthless when merely sprayed over the fabric in a casual manner. It is believed that the present use of so-called moth proofing solutions by certain fabric manufacturers will either automatically stop moth damage or will force the manufacturers of the solutions to withdraw their extravagantly worded advertisements.

Discussed by SIEGLER and GRAF.

J. S. WADE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. ROBERT B. SOSMAN has resigned from the Geophysical Laboratory, Carnegie Institution of Washington, to join the staff of the newly established Department of Research and Technology of the U. S. Steel Corporation, with headquarters at the plant of the Federal Shipbuilding and Dry Dock Co., Kearny, New Jersey.

WILLIAM R. MAXON Associate Curator, Division of Plants, National Museum, left for Europe on July 4, to study the fern collections of several of the larger European herbaria. Mr. Maxon's principal investigations will be carried on at the British Museum and at the Royal Botanic Gardens, Kew, in connection with the preparation of the fern volume of the Flora of Jamaica, a work now in course of publication by the British Museum. From England Mr. Maxon expects to go to Stockholm, Copenhagen, Berlin, and Paris, and will return to Washington in October.